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PERIODIC WIND VARIATIONS

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WITHIN A 24-HOUR PERIOD variations of the wind occur at most continental localities for a variety of reasons. Over the central United States this variation often reaches an amplitude of 50 miles per hour between night and day at about 2500 feet elevation. The strong nighttime surge has been responsible for many airplane landing accidents, is a factor in the spread of forest fires, is probably the principal cause of nocturnal torrential rains and thunderstorms in summer throughout the Midwest, and appears to be significant to migrating song birds.

ANEMOGRAPH records show that the wind is forever changing. Most of the variations are irregular in nature and are distributed continuously through a spectrum ranging from periods of many years down to a second or less. The longer period variations are associated with migratory cyclonic and anticyclonic disturbances, seasonal anomalies of temperature or precipitation, and even climatic changes of circulation. The shorter disturbances are turbulent in nature and result from convection above heated surfaces or from the mechanical action of irregularities in the underlying surface. Superimposed upon all these irregular disturbances are regular variations with annual and diurnal periods. The nature of the diurnal variation differs with the characteristics of the locality, but in every case it arises from the diurnal cycle of heating and cooling.

Varieties of Periodic Winds

The irregular fluctuations can be separated from the daily ones by grouping a long period of wind records according to the time of the day and by averaging each hour separately. By the application of this procedure a number of different types of variations can be recognized. In coastal areas there is found the sea breeze phenomenon: onshore winds developing as the land is heated up rapidly during the day; offshore winds setting in at night as the land cools to a temperature below that of the sea. Another kind of periodic circulation is found in sloping valleys and on the slopes of mountains: up the slope during the day and down the slope at night. Both the sea breeze and mountain wind circulations are caused by temperature differences due to unequal heating of an air mass. The cooler air seeks a lower center of gravity either by sinking or by spreading out, and during the process some of the atmospheric potential energy is converted into kinetic energy. Another type of variation arises from small pressure variations caused by the direct heating and cooling of the atmosphere by solar radiation. This type is found almost everywhere in the free atmosphere and is the only type of variation found over the ocean. It is the smallest of the recognized diurnal variations, reaching a maximum amplitude of about 1 mile per hour near the tropopause (at a height of about 8 miles).

The most striking periodic wind systems are found over the middle latitude continents. The characteristics of the variation differ with elevation. In the surface layers up to a height of 15 to 100 meters, depending on the roughness of the surface, the wind reaches a maximum speed during the hottest time of the day and decreases to a minimum sometime between midnight and dawn. Observers on towers or mountain tops which extend above the surface layer find the opposite kind of variation, a maximum speed occurring sometime between midnight and dawn. For a small range of heights near the top of the surface layer, a semidiurnal variation is observed with maxima occurring both in the afternoon and in the predawn hours. Above the surface layer the range of the diurnal variation increases with height to a maximum at about 2500 feet above the ground and does not usually disappear until a height of at least 7000 feet above the surface is reached. The magnitude of the variation is greatest at localities which are far from the ocean, where the underlying surface is dry and smooth and where the wind itself is usually moderately strong. Other things being favorable, it is usually greatest near 30° latitude. In the United States the greatest range of variation occurs over the Great Plains from Oklahoma to Nebraska, where the range may exceed 50 miles per hour.

The physical cause of the typical continental variations was first recognized by Espy [10] in 1841. Owing to the drag which the surface exerts on moving air, the wind speed usually increases with height up to at least 3000 feet above the ground. During the daytime, convection above the heated ground causes considerable mixing between the surface and the upper layers. The ascending bodies of air originating at low levels are replaced by descending air parcels from higher levels which tend to bring down with them the higher speeds prevalent at those levels. As this momentum is im-

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PERIODIC WIND VARIATIONS—

(Continued from page 1)

parted to the surface air by mixing, the speed of the wind at the surface increases until the enhanced supply of momentum is matched by the loss at the surface through frictional drag. The daytime decrease of the wind above about 300 feet was probably unknown in Espy's time, but it too is explained by the same mechanism. The momentum which the surface layers have gained represents a corresponding loss by the upper strata; therefore, their speed lags behind the equilibrium value. At night convection ceases and with it the exchange of momentum between the lower and upper layers. Deprived of its momentum source and exposed to the frictional drag of the ground, the surface air slows down, while the upper layer is once again freed of its restraint and begins to speed up under the combined influence of the horizontal pressure gradient and the rotation of the earth. This kind of diurnal wind variation does not occur over the ocean because there is no variation of the temperature at the ocean surface.

The mechanism of transfer of momentum between two layers by the exchange of air bodies is rather similar to that employed by Maxwell to explain the viscosity in gases. By following a course of reasoning analogous to the kinetic theory, one can show that the effective viscosity (eddy viscosity) in a turbulent regime is proportional to the velocity and size of the circulations responsible for the exchange of momentum between levels. During convective activity in the daytime the eddy viscosity is more than ten times as large as during the night and more than a million times larger than the ordinary molecular viscosity.

The Low-level Jet Stream

Normally the wind increases upward through the layer of frictional influence up to 3000 feet at least, and in temperate latitudes it continues to increase with height up to 30,000 feet or more. It is, therefore, interesting that on some occasions a strong jet-like maximum of speed is observed at a height between 1000 feet and 2000 feet, above which the speed decreases to much smaller values. The phenomenon was frequently observed during a three-year series of experimental kite observations at Drexel, Nebraska, between 1916 and 1918. Similar jets have been found in pilot balloon observations of the wind at Ft. Lamy and Khartoum in the southern portion of the Sahara during the season of the northeast trades. Over the United States recent studies [2] have shown that this phenomenon occurs almost everywhere in clear weather during the nighttime hours. The strongest and most frequent jets occur in the region of the Great Plains. Unlike the jet stream which is situated at greater heights (30,000 to 40,000 feet) this low-level jet stream usually covers a wide horizontal area. Rather than looking like a river, it is as if a sheet of rapidly moving air were sandwiched between slower layers above and below.

The low-level jet stream usually develops at night in connection with the strong nocturnal increase of wind that is normally found at upper levels. The evolution of a jet profile as part of the diurnal wind cycle is well illustrated in Figure 1 which has been made from special wind observations by Gifford [11] at Silver Hill, Md., a few miles southeast of Washington, D. C., during a period when the pressure was not changing. During the afternoon (1600 EST), the wind at the nearby Washington Airport was increasing at all levels up to 4000 feet. After sunset, the wind increased very strongly between 1000 and 3000 feet, thus forming a jet profile. By 0500 EST, two hours before sunrise, the strength of the jet had already begun to diminish, and by midday it had disappeared altogether.

The dynamics of the low-level jet stream are both interesting and useful in giving information indirectly about the distribution and variability of low-level atmospheric mixing processes. For this purpose it is helpful to describe the principle of balanced motion which prevails in the nearly frictionless domain above 3000 feet. The horizontal pressure gradient causes a horizontal force which tends to accelerate the air in the direction of lower pressure. The rotation of the earth influences every moving particle by giving rise to the Coriolis force, which always acts to the right of the direction of motion in the northern hemisphere with a magnitude proportional to its velocity. In the absence of friction, the acceleration ceases when the air moves parallel to the isobars at a speed proportional to the pressure gradient. The force of the pressure gradient is then to the left of the direction of motion and is exactly opposite to and balanced by the Coriolis force. The velocity of the air moving in equilibrium with the pressure gradient is called the gradient wind.[1]

Lettau found [14] that the velocity of the wind in a jet observed at O'Neill, Nebraska exceeded the gradient wind speed by a very substantial margin. A similar conclusion was reached by the author [2] in a study of 16 low-level jets which occurred at San Antonio during the month of January 1953. The comparison of the jet speeds and the gradient wind speed, shown in Figure 1, is typical of that found in all of the jets which have been studied. It was suggested by the author that the strong winds at the jet level can be explained as an inertia-type oscillation which is initiated by the frictional drag at the ground during the daytime. This explanation is described more fully below.

Inertia oscillations occur when the wind is disturbed from the equilibrium value and is subsequently allowed to change under the sole influence of the pressure gradient and Coriolis forces. The changes which the wind undergoes in this case can be explained by reference to Figure 2. The vector OG represents the wind which would be in equilibrium with the existing pressure distribution. The actual wind at the initial time is represented by OW_0, and the vector which indicates the disturbance from equilibrium is GW_0. If the air is free to accelerate without influence from friction or other disturbing forces, the motion changes in such a way that the disturbance vector rotates toward the right in the northern hemisphere, while maintaining a constant magnitude so as to be situated in the position of GW several hours later. The wind at that time is then indicated by the vector OW. As long as other forces do not act on the system, the vector GW continues to rotate to the right and returns to the initial vector GW_0 after a period which varies with the latitude. At the North Pole the period is 12 hours, and at 30° it is exactly one day. Inertia oscillations have been observed in ocean currents [18], and it is believed that the large amplitude of the sea breeze at around 30° latitude is a resonance resulting from the superposition of the periodic, thermally induced, land-sea force upon an inertia oscillation with the same one-day period [13].

The low-level jet stream occurs at an intermediate height within the layer of frictional influence. Near the surface, friction slows down the motion at all times, and, therefore, no inertia oscillation is possible. At much greater heights; i.e., above 2000 meters, there is no frictional retardation either in the night or in the day. There is, therefore, no disturbance linked to the diurnal cycle to initiate an oscillation, although conditions would be favorable if it once got started. At the intermediate level where the jet develops, the air is strongly retarded by friction during the day, but as the eddy viscosity diminishes rapidly at about sunset, the air at this level is able to move almost frictionlessly during the night.

Thus at sunset the motion is initially retarded from the gradient velocity as is OW_0 in Figure 2. With the cessation of the mixing with lower levels, the vector GW_0 begins changing toward GW. Eight to twelve hours later (in the United States) the maximum velocity is reached. At this time the vector GW is in the same direction as the gradient

[1] When the motion is curved, a small correction to the velocity is made for the effect of centrifugal force.

wind vector OG, and the wind vector OW then exceeds the gradient speed. In the Midwest the maximum speed is as much as 25 mph stronger than the gradient wind speed and 50 mph stronger than the daytime speed. The manner in which a jet profile is believed to develop from inertia oscillations at each level is illustrated in Figure 3. The maximum wind speed usually is found at the top of the nocturnally cooled layer, and this level is the lowest one where a free oscillation takes place. Within the cooled layer there is sufficient turbulence generated by the strong wind shear to cause a weak but significant downward loss of momentum.

Many observations have confirmed a turning of the wind vector as shown in Figure 2. Instead of sweeping out a circle, however, it is usually found to trace out an elliptical path with the longer axis in the direction of the wind. Recent theoretical studies by Buajitti and the author [5] have shown that the elliptical variation results from the fact that the viscosity does not drop abruptly to zero at sunset, but diminishes rather gradually during the late afternoon and evening. These studies also seem to indicate that the observed orientation and range of velocity can be explained only if both the average magnitude of the eddy viscosity and the range of its variation increase from very small values near the ground to a maximum somewhere below the jet level and then decrease with height. This pattern of variation has been noted elsewhere. Not all aspects of the periodic wind variation associated with low-level jet streams have been satisfactorily explained, and it is quite possible that other periodically varying forces may be found to exert a significant influence in these oscillations. A suggestion by Bleeker and Andre [4] that the oscillations on the Great Plains are initiated by down-slope drainage of nocturnally cooled air does not appear to be valid, since it has been shown that oscillations which could be produced by this mechanism would have the wrong phase [5].

Importance for Flying Safety

Occasionally an aircraft pilot finds himself unable to prevent a premature landing short of the end of the runway. The airplane seems to lose its lift despite efforts of the pilot to correct the stalling tendency by the quick application of power. Many of these accidents are serious, and the number of cases has risen sharply with the advent of jet aircraft.[2] For many years these accidents were blamed on pilot error, despite the fact that they happened to men with many years of experience, until the cause was traced to the occurrence of an extremely large vertical shear of the wind. Such a situation develops beneath the low-level jet stream when very light winds prevail at the ground beneath a layer of high wind speed a few hundred feet higher up.

Neyland [16] has described the effect of wind shear on an aircraft approaching for a landing. At the beginning of the approach, while still at a height of several hundred feet, the aircraft is encountering a strong headwind. While maintaining a sufficient airspeed for lift, the airplane is moving more slowly relative to the ground. As the airplane glides down, maintaining a fixed ground speed, the air speed begins to diminish because of the decreasing speed of the head wind at lower levels. An experienced pilot instinctively corrects for the resulting loss of lift by increasing the glide angle. However, this procedure causes a more rapid drop to levels with still smaller head wind. Fast action to increase air speed is the only salvation. Here certain types of jet aircraft have a serious difficulty in that several seconds elapse after the throttle is pushed before full thrust is developed. Accidents of this type need not occur if the pilot is prepared for the situation, for he can plan his approach accordingly and keep extra power quickly available. The hazard arises because excessive wind shear is very infrequent so that the pilot is taken by surprise and fails to react quickly enough.

[2] According to personal communication from Capt. Thomas B. Gray, U.S.A.F.

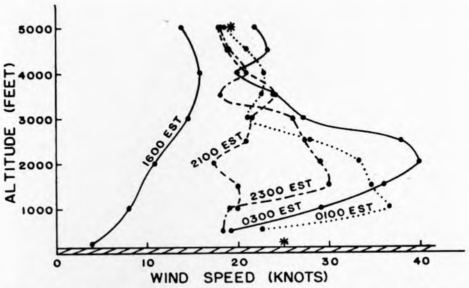


Figure 1. Evolution of a low-level jet stream at Silver Hill, Md., on the night of October 30-31, 1950. Observations were made by Gifford [11]. Asterisks at the surface and at 5000 feet indicate the gradient wind speed.

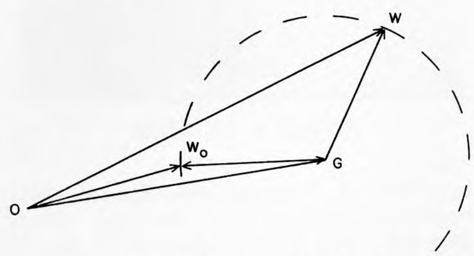


Figure 2. Wind changes during an inertia oscillation. Initial and subsequent wind vectors are OW_0 and OW, respectively, and OG is the gradient wind.

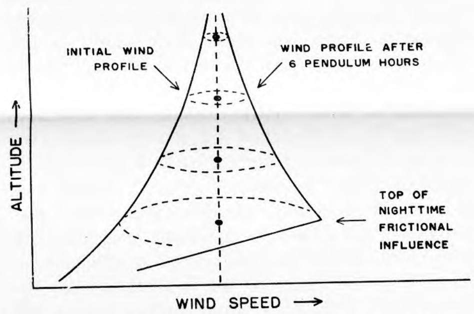


Figure 3. Schematic illustration explaining the evolution of a boundary layer jet profile.

Probably the best solution of the problem lies in giving the pilot advance warning of the existence of strong wind shear. Continuous observation of wind shear might be accomplished by the erection of a tall tower or perhaps by flying a captive balloon bearing remote indicating wind instruments, but neither of these platforms is feasible within the proximity of airports. In a few cases existing towers at nearby cities might be instrumented and used for this purpose. In most situations, however, the more expedient solution is a short-range, objective, forecasting procedure which is capable of predicting the occurrence of excessive wind shear from data three to nine hours old.

Such a method has been developed at The Pennsylvania State University under sponsorship of the Geophysics Research Directorate of the Air Force Cambridge Research Center [3]. A climatic survey showed that dangerous wind shear is mostly confined to the Great Plains region, that it occurs mainly at night under low-level jet streams, and that insofar as it is related to these jets, it occurs about as often in summer as in winter. The strongest wind shear which has so far been encountered was observed near Drexel, Nebraska, during a period of experimental kite observations of upper winds and temperatures on March 18, 1918. The wind increased at a nearly constant rate from 6 mph near the ground to 81 mph at 780 feet where the jet stream maximum was situated.

The development of the forecasting procedure was aided by an understanding of the physical causes of the low-level jet. The requirements for a well-developed jet stream during the night are clear weather, rapid warming near the ground during the daytime, rapid cooling at night, and a moderate pressure gradient. These physical conditions are best met in the Great Plains when winds in the lower layers are from the south. After many different prediction parameters suggested by physical considerations had been tried, it was found best to use the wind direction and speed during the afternoon as the basis. From the study of data collected for about a year, objective criteria were worked out to make it possible even for an inexperienced person, following simple rules, to determine from the midafternoon wind observation at three stations whether excessive wind shear will occur during the succeeding night. The method was tested during an independent nine-month period. Forecasts of the occurrence or nonoccurrence of wind shear greater than 23 knots in the lowest 1000 feet at Tulsa, Oklahoma, were correct 84 per cent of the time, and every one of the 17 occurrences of wind shear greater than 27 knots per 1000 feet were correctly forecast. Thus the method seems to be extremely accurate in precisely the situations where it is most needed.

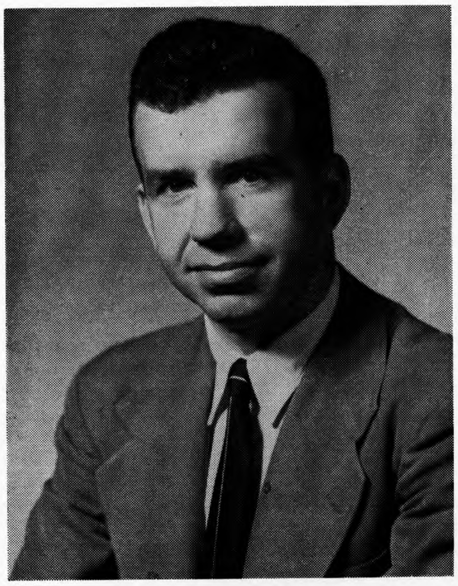
Relations to Other Atmospheric Phenomena

A surprising number of atmospheric phenomena can be traced to the effects of wind oscillations. For example, the shear which develops at night underneath a low-level jet stream often becomes so strong that the flow becomes unstable and begins to become turbulent. For perhaps half an hour the surface wind becomes strong and gusty, and the surface temperature rises several degrees as warmer air is brought down by the gusts and mixed with the colder air at the ground. Examples of this phenomenon have been described by Durst [8] and Gifford [11].

In most localities there is a maximum of thunderstorm frequency during the late afternoon, but in a four-state area centered in the vicinity of Omaha during July and August most of the thunderstorms occur at night. The afternoon maximum observed at most localities is associated with the maximum surface temperature and the consequent tendency for overturning of a deep layer. However, the nocturnal maximum observed in the Midwest has been one of the classical enigmas of meteorology, for the thunderstorms occur at a time when the surface is cooling rapidly. The phenomenon probably has a number of causes, at least two of which are connected with wind oscillations and the low-level jet stream.

Conditions are most favorable for the development of thunderstorms when warm, moist air becomes situated beneath very cold air at higher elevations. To initiate thunderstorms, a lifting of the air mass is often, although not always, necessary. The nocturnal thunderstorms usually occur during situations when the wind is moving from the south or southwest direction in such a manner that warmer air is brought in at the level of the low-level jet stream. During the daytime this horizontal transport of warmer air is rather feeble owing to the weakness of the winds two or three thousand feet above the ground (for example, see Figure 5). According to a hypothesis introduced by Means [15], the much stronger winds which occur at this level at night increase the rate of horizontal warm air advection to a degree which more than offsets the effect of the cooling at the ground. The resulting tendency for increased instability at night is augmented by a higher humidity of the lower layers, caused by the same process. This humidity promotes the release of the instability by lowering the condensation level and increasing the release of latent heat.

Another and probably more important action of the low-level jet stream is its lifting effect [5]. For reasons which were described above, the low-level jet stream develops most strongly over the vast areas of the Great Plains. It develops only weakly or not at all over the Great Lakes and surrounding forested areas, since these surface features do not favor the extremely rapid cooling which occurs over the plains. As the jet stream surges northeastward it runs into the feebler current and begins to squeeze out the air between, forcing the air to ascend. Usually the ascent is sufficient to begin condensation in at least some parts of the area, and the resulting release of latent heat triggers the thunderstorm convection. A typical example of this process is shown in Figure 4. At 3 a.m. the strong low-level jet stream which developed over the



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large area of Iowa, Missouri, Kansas, Oklahoma, and Texas overtakes the weak current over the Great Lakes, indicated by the 20 mph wind at Sault Ste. Marie and 10 mph wind at Duluth. The air over Wisconsin, Illinois, and Minnesota is squeezed and forced to ascend. The situation so depicted produced thunderstorms about this time in these three states. In the daytime an opposite situation usually prevails to a somewhat smaller degree. Figure 5 shows the wind distribution at the same level at 3 p.m. on the following afternoon. The low-level jet stream has disappeared, as it normally does in the daytime, and has been replaced by a very weak current with speeds ranging from 5 to 15 mph. The air over the lakes has not experienced this rapid decrease, because the water and forest surfaces have been heated far less than the open plains. This air moves northeastward more rapidly than the air behind it over the plains. Air subsiding from higher levels fills the spreading hiatus between these currents — a process tending to dissipate the convective clouds and to end the thunderstorm activity.

Dexter [7] has drawn attention to the fact that warm frontal precipitation tends to be heavier and more extensive at night than in the daytime. The precipitation is caused in this case by a northward-moving air mass meeting the sloping surface of a colder air mass and being forced to ascend adiabatically up the surface. Because of the nocturnal increase of winds in the lower few thousand feet, the overrunning air tends to be pushed more rapidly up the sloping surface during the night than during the day. This effect is noticeable in much of the precipitation over the United States and contributes to much of the nocturnal thunderstorm activity in the Midwest.

Forest Fire Blowups

Occasionally it happens that the forward progress of a forest fire is greatly accelerated by a sudden intensification of the burning and subsequent scattering of flaming material over a wide area. The rising air column, made partially visible by smoke and debris, develops as if contained within a chimney. At the surface, air rushing in toward the fire increases the vigor of the flames and may become rapid enough to pick up large flaming objects and to hurl them for considerable distances. In some cases fierce fire whirlwinds have been reported with an intensity sufficient to pick up logs and to snap off large pines at the base of the trunk [12].

Byram [6] has made a study of the meteorological conditions which favor the blowup of forest fires in the southeastern United States and has found that a jet profile such as that in Figure 1 is required. The reason for this association is not known. It is speculated that the high wind speeds at relatively low levels aid in keeping the fire front moving at moderate speed, while the slow winds at higher levels prevent the "chimney" from moving out ahead of the fire where it would cease to be effective.

Bird Migration

In terms of sheer numbers, the principal beneficiaries of the wind oscillations that have

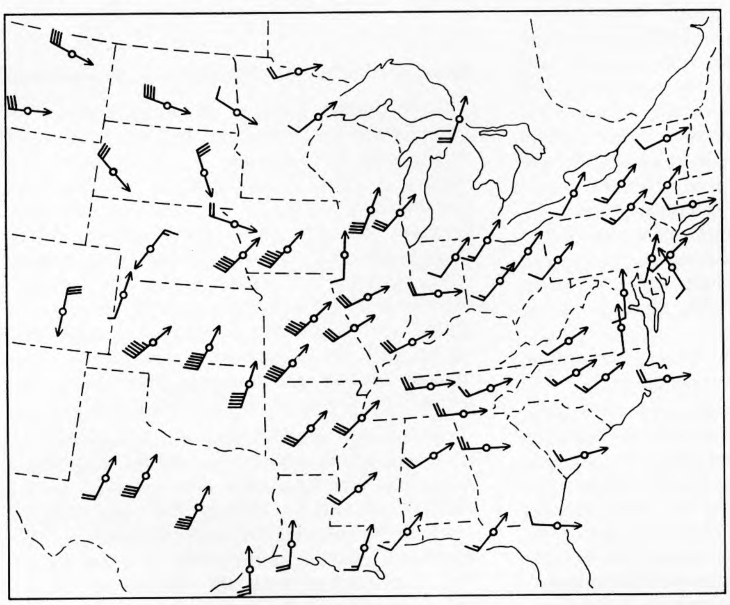

Figure 4. Wind distribution 2000 feet above the ground at 0300 CST on July 8, 1955. Each full barb represents a speed of 10 miles per hour; two barbs, 20 mph; half barb, 5 mph; etc. Arrows fly with the wind.

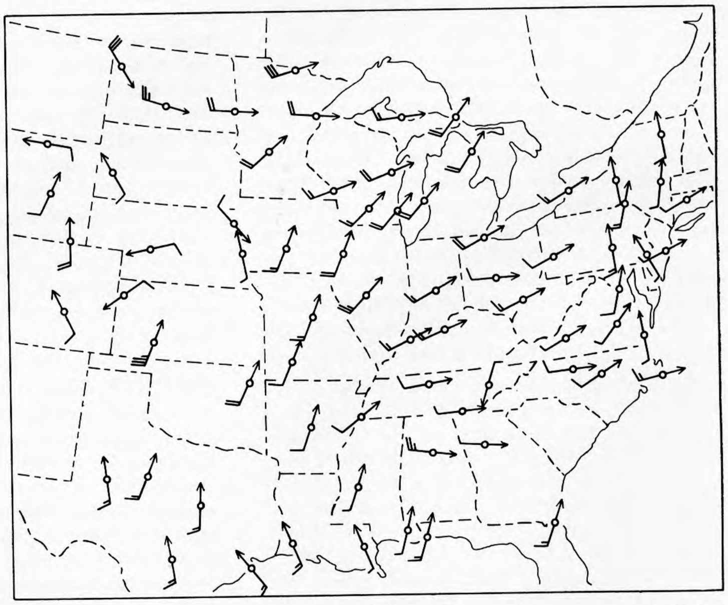

Figure 5. Wind distribution 2000 feet above the ground at 1500 CST on July 8, 1955. Each full barb represents a speed of 10 miles per hour; two barbs, 20 mph; half barb, 5 mph; etc. Arrows fly with the wind.

been described are the hosts of migrating song birds. Telescopic observations of birds transiting the face of the moon have helped to establish the fact that most of the song bird migration occurs at night at levels of the order of 1000 to 3000 feet. These observations, together with analyses of thousands of records of bird arrivals and departures at localities in the United States have established the fact that the large northward movements in spring are confined to the region of warm air flow from the south or southwest direction which occurs in the southeastern portion of a cyclone. The migration ceases abruptly with the passage of a cold front and the accompanying fall of temperature and shift to wind from the northwest [1]. Correlations of bird movements with the surface temperature are low, but the movements do correlate well with falling pressure which normally occurs in the southeast portion of a cyclone.

Raynor [17] has found that the northward bird movements in spring occur mainly on nights when there is a strong increase of temperature with height in the lowest few hundred feet. He suggested a theory that the absence of turbulence in such a temperature regime makes it easier for birds to fly and to navigate.

A more plausible explanation of the preference of migrating birds for nights with strong temperature inversions is that this situation is the most favorable one for the development of a strong low-level jet stream and that the birds are able to locate and make use of the resulting strong tail winds at these levels to speed their flight. Wind speeds of 50 or 60 mph are common in these jets and more than double the birds' normal speed over the ground. Southward migrations in autumn show a preference for cold nights when the winds are from the north at their flight levels. These nights are frequently quite gusty and turbulent. In this season the nocturnal migrants avoid nights with a strong temperature inversion above the ground if an opposing low-level jet stream exists at one or two thousand feet. Presumably the birds make short test flights early in the evening and, finding unfavorable winds, descend to wait for a better night.

References

1. Bagg, A. M., W. W. H. Gunn, D. S. Miller, J. T. Nichols, W. Smith, and F. P. Wolfarth, 1950: Barometric pressure patterns and spring bird migration. *Wilson Bull.*, v. 62, pp. 5-19.
2. Blackadar, A. K., 1957: Boundary layer wind maxima and their significance for the growth of nocturnal inversions. *Bull. Amer. Meteor. Soc.*, v. 38, pp. 283-290.
3. Blackadar, A. K., and G. C. Reiter, 1958: Objective forecasting of low-level wind shear. Scientific Report No. 1, Contract No. AF19(604)-2059, The Pennsylvania State University.
4. Bleeker, W., and M. J. Andre, 1951: On the diurnal variation of precipitation particularly over the central USA and its relation to large scale orographic circulation systems. *Quart. Jour. Roy. Meteor. Soc.*, v. 77, pp. 260-271.
5. Buajitti, K., and A. K. Blackadar, 1957: Theoretical studies of diurnal wind variations in the planetary boundary layer. *Quart. Jour. Roy. Meteor. Soc.*, v. 83, pp. 486-500.
6. Byram, G. M., 1954: Atmospheric conditions related to blowup fires. Station Paper No. 35, Southeast Forest Experiment Station, Asheville, N. C.
7. Dexter, R. V., 1944: The diurnal variation of warm-frontal precipitation and thunderstorms. *Quart. Jour. Roy. Meteor. Soc.*, v. 70, pp. 129-137.
8. Durst, C. S., 1933: The breakdown of steep wind gradients in inversions. *Quart. Jour. Roy. Meteor. Soc.*, v. 59, pp. 131-136.
9. Eaton, E. H., 1904: Spring bird migration of 1903. *Auk*, v. 21, pp. 341-345.
10. Espy, J. P., 1841: *The Philosophy of Storms.* Charles Little and James Brown, Boston; 552 pp.
11. Gifford, F. A., 1952: The breakdown of a low-level inversion studied by means of detailed soundings with a modified radiosonde. *Bull. Amer. Meteor. Soc.*, v. 33, pp. 373-379.
12. Graham, H. E., 1955: Fire whirlwinds.

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SCHOLARSHIPS 1958-1959

Scholarship	Amt. Per Year	Recipient	Home Town	Year
CERAMIC TECHNOLOGY				
American Ceramic Society (Phila. Section)	$ 350	Jesse J. Brown, Jr.	Newport	Freshman
American Encaustic Tiling	500	Thomas J. Branch	Charleroi	Freshman
Garfield Refractories Co.	500	Irvin R. Shore	Tarentum	Freshman
	500	Susan Kurtossy	State College	Freshman
General Refractories Co. Senior Scho.	500	James S. Reed	Cochranton	Junior
Harbison-Walker Refractories Co.	500	Gary K. Bergholtz	Port Allegany	Sophomore
	500	James L. Liberto	Ford City	Senior
	500	William G. Sekeras	Tarentum	Senior
Haws Refractories Co.	500	Charles L. Booth	West Hazleton	Junior
O. Hommel Co. Memorial	500	Eric Kreidler	Flemington	Sophomore
E. J. Lavino Co.	500	Dael E. Copeland	Philadelphia	Senior
National Refractories Co.	500	Thomas C. Reeder	Beaver Falls	Freshman
North American Refractories Co.	500	Donald J. Veater	Uniontown	Senior
Pa. Ceramics Association	250	Joseph K. Scheitle, Jr.	Freeport	Freshman
Pa. Glass Sand Corp.	350	Leonard M. Cook	Ford City	Senior
Pfaudler Co.	500	Charles E. Houck	Bethlehem	Freshman
	500	Anthony Perrotta	Erie	Junior
Pittsburgh Plate Glass Co.	500	Mary M. Beyer	Julian	Freshman
	500	Daniel R. Stewart	Arnold	Junior
	500	Ronald L. Beatty	Clarksburg	Sophomore
	500	Joseph Kerenick	Kittanning	Freshman
H. K. Porter Co.	500	Not yet awarded		
Stackpole Carbon Co.	500	Ray K. Reeder	Beaver Falls	Junior
Hiram Swank's Sons Refractories Co.	500	Charles R. Beechan	Cairnbrook	Sophomore
Swindell-Dressler Found.	500	Glenn H. Rees	Clearfield	Senior
Vesuvius Crucible Co.	500	Ronald V. Kilgore	Leechburg	Sophomore
	500	Domeinc C. Cuffia	Leechburg	Sophomore
FUEL TECHNOLOGY				
American Coal Sales Assoc.	1000	Gerald P. Duckett	Clearfield	Junior
	1000	Frank J. Cole	Ashley	Freshman
Anonymous	500	Peter T. Luckie	Hanover	Junior
Bituminous Coal Research, Inc.	500	Joseph E. Metcalfe	Stockdale	Junior
	500	Charles E. Myers	Philadelphia	Freshman
Consolidation Coal Co.	500	Robert R. Luckie, III	Hanover	Junior
	500	Jesse O. Mapstone, Jr.	Hellam	Freshman
	500	Peter J. Hart	Canonsburg	Sophomore
	500	William W. Nelson	Cresson	Freshman
	500	George T. Craig	Library	Freshman
Eastern Gas & Fuel Assoc.	500	Eugene L. Grumer	Pittsburgh	Sophomore
	500	John F. Beamer	Greensburg	Junior
	500	Barrie R. Wilson	Punxsutawney	Freshman
Koppers Co.	500	John G. Sotter	Springfield	Sophomore
National Coal Assoc.	500	Edward H. Klebacha	Reynoldsville	Sophomore
	500	Leslie V. Shaffer	Harrisburg	Junior
Texas Company	425	Sarah M. Kemberling	Everett	Junior
MINERAL ECONOMICS				
E. J. Lavino Co.	500	Ronald D. Smith	Mercersburg	Sophomore
MINING				
Matthew J. Wilson†	600	Robert Hellmuth	Harrington Park, N. J.	Freshman
PETROLEUM & NATURAL GAS				
Edwin L. Drake Memorial	350	E. Forest Mintz	Oil City	Senior
Socony-Mobil Oil Co., Inc.	750	Donald B. Megahan	Meadville	Senior

† This scholarship open to students in all Mineral Industry curriculums.

(Continued on page 8)

The Mineral Base of the European Economic Community

JOHN D. RIDGE*

EEC — Purposes and Organization

THE EUROPEAN ECONOMIC COMMUNITY (EEC) commenced operations at the beginning of the year. This organization, established by Belgium, the Netherlands, Luxemburg, France, West Germany, and Italy, is designed to provide a common market in which essentially all barriers to the flow of goods, services, manpower, or investment capital from one country to another are gradually to be removed. This free movement is to be insured by the reduction and eventual elimination of customs duties and quotas among the member states; by common tariff and commercial policies toward countries not members of the EEC; by the removal of all regulations against free movement of persons, services, and capital, as well as of goods, within the six-nation community; and by the integration of agriculture and transportation within the EEC. To facilitate the transition to essentially free competition in the business operations of the community, certain funds have been established to finance projects of value to the community as a whole, to aid the adjustment of labor to new conditions, and to advance the development of overseas territories of some of the member states.

The EEC is to be controlled by several supernational agencies, of which the Assembly and Court of Justice will be shared with Euratom (the joint development program for atomic energy) and the European Coal and Steel Community. The EEC will, however, have its own Council of Ministers and its own Common Market Commission. Of these, the former is largely the policy-making body of the EEC. The latter not only carries out day-to-day supervision as directed by the Council but also decides technical questions of the application of the enabling treaty and presents to the Council recommendations on basic issues which the Council, after study, may or may not approve. In addition to these executive groups, there are two advisory bodies, the Economic and Social Committee and the Monetary Committee, the members of which in effect represent both the member governments and the executive groups. Both committees are to submit reports of current problems to the Council and the Commission for their information and guidance.

The EEC will gradually merge the member nations into a single economic unit over the next 12 to 15 years. Internal customs duties are to be gradually reduced and by the end of 1965 should be less than half what they were on January 1, 1957. At the end of the first 10 years, the tariff reductions are to have been supplemented by fixing all import quotas at no less than 20 per cent of the domestic production of the item in question. With a few possible exceptions, all import quotas are to have been eliminated by the end of the 12-15-year period, and all export quotas are to have been removed by the end of the first 4-year period.

External tariffs are normally to be the average of the rates of the four present customs units (the Benelux countries have long been such a unit), although special provisions will somewhat increase the average common tariff. No state will be allowed to make unilateral changes in any schedule; unanimous consent will be required for any modifications of rates. Most tariffs have already been set, but some (List G) remain to be negotiated.

To achieve a true customs union, the member states must permit the free movement of capital and labor within their common borders. Not only will persons and capital be allowed to cross national borders without hindrance, but also restrictions on setting up businesses, branches, agencies, or subsidiaries in another country of the Community will gradually be removed during the transition period. The program to accomplish this last is to be worked out in the first four-year period. Within the first two years, the elimination of any restrictions on such services as those of banks, lawyers, and insurance firms is to be planned by the Commission, subject to a somewhat complicated scheme of acceptance by the Council.

The enabling treaty also requires the removal of any rate differentials among common carriers of the six countries as well as any other conditions through which movement from the country of origin or to the destination are adversely affected. Such new regulations as are needed to achieve these goals are to be set up by the Council by December 31, 1960. Until this is done, present arrangements may not be made more onerous for any member country than they are for domestic carriers.

Although cartels have been characteristic of European economic activity, the EEC will encourage the active stimulation of competition and the admission of new firms into such cartels as do exist. The treaty prohibits many of the usual activities of cartels but allows practices, agreements, and mergers "which contribute to improve the production or distribution of goods or to promote technical progress" provided consumers "receive a fair share of the benefits." In the probably expanding internal market of the EEC, the economic climate will be somewhat less favorable for cartels than at present, but it is to be

* Professor and Head, Department of Mineral Economics.

European Mineral Production,

(in thousands of tons)

Product	EUROPEAN ECONOMIC COMMUNITY 1947-1951 Average	1955	1956	1957	WESTERN EUROPE (Total) 1947-1951 Average	1955	1956	1957	U. S. S. R. 1947-1951 Average	1955	1956	1957
Iron Ore	45,176	82,275	87,095	94,725	78,428	128,875	136,983	147,933	39,031	79,233	85,979	91,046
Steel	30,163	56,962	62,664	65,964	50,093	86,848	93,109	97,362*	25,600	50,000	53,600	56,217
Copper in Ore	1.7	1.7	1.5	2.1	62.6	68.2	69.4	82.0	224.0	385.0	416.0	450.0
Smelter Copper	143.0	286.6	279.9	280.0	199.9	363.4	358.8	386.0	224.0	385.0	416.0	452.0
Lead in Ore	86.5	140.3	134.6	149.4	160.4	274.0	268.0	279.9	103.2	255.0	290.0	310.0
Smelter Lead	217.5	333.6	361.5	383.7	284.1	449.5	475.9	506.7	103.2	255.0	290.0	320.0
Zinc in Ore	156.1	244.9	250.5	261.9	274.0	467.7	501.3	505.2	138.0	300.0	351.0	386.0
Slab Zinc	396.8	662.5	701.1	720.5	541.2	740.5	779.1	891.4	138.0	300.0	351.0	386.0
Bauxite	986.5	1,793.8	1,703.1	1,915.4	1,070.7	2,311.2	2,422.3	2,731.6	659.0	984.0	1,083.0	1,230.0
Aluminum	139.5	361.5	397.4	419.1	259.7	587.2	659.8	693.6	179.7	475.0	500.0	550.0
Magnesium	0.8	5.0	6.0	6.3	4.6	18.5	17.7	18.1	22.9	55.0	60.0	60.0
Manganese	27.4	62.4	50.7	51.8	55.8	142.3	117.9	126.1	3,238.6	5,228.3	5,235.0	5,467.5
Mercury	1.9	2.0	2.4	2.4	3.4	3.4	3.9	4.3	.44	0.47	0.47	0.50*
Molybdenum#	neg	neg	neg	neg	200	397	385*	401	na	na	na	na
Barite	327.8	613.4	607.9	616.2	498.0	748.8	749.4	765.8	99.0	110.0	110.0	110.0
Fluorspar	156.1	358.8	398.9	401.4	285.2	530.5	544.8	595.5	83.6	110.0	110.0	165.0
Potash, equiv K_2O	1,815.1	3,177.8	3,278.2	3,391.0	1,631.4	3,420.9	3,536.5	3,673.8	274.0	870.5	983.6	1,040.0
Pyrites, gross wt.	1,458.6	2,176.2	2,282.7	2,359.6	4,749.4	6,941.6	7,029.4	7,030.6	na	na	na	na
Silver°	2,193.2	3,439.7	3,464.7	3,398.4	4,360.3	7,776.8	8,408.7	7,839.5	17,860.0	25,000.0	25,000.0	25,000.0
Coal: Bituminous	174,100	272,957	276,013	274,543	401,626	536,039	540,039	541,695	195,000	304,941	334,772	360,455
Lignite	74,180	104,607	110,191	112,034	81,682	115,725	122,211	157,741	39,000	126,348	138,340	149,914
Petroleum°°	11,800	37,304	46,614	58,549	20,800	62,190	70,233	78,964	238,900	509,760	611,740	na

* Estimated ** East Germany only † Poland only ‡ Czechoslovakia only ° In 1000's of ounces °° In 1000's of barrels

Sources: American Iron and Steel Institute, U. S. Bureau of Mines.

doubted that the EEC will largely eliminate them from the scene.

The Western European Free Trade Area

The negotiations for the formation of the common market had not proceeded far before other European countries recognized that their economic positions would be seriously affected. It would be, for example, very difficult for a British manufacturer who now pays the same French rate of duty as his German competitor to retain his market when his German opposite number is relieved from all, or at least most, French tariff charges. Had these other European countries been willing to accept the entire EEC program, they could probably have been admitted to it. Most of them, however, for one reason or another could not or did not desire to accept all the terms of the EEC treaty; the British, for example, would have been forced to give up their preferential tariff agreements with the other Commonwealth members. To obtain some of the benefits of the EEC and at the same time to maintain their previous arrangements, the British and several other Western European countries suggested the formation of the Free Trade Area (or the European Economic Association). The FTA would have begun operations at the same time as the EEC and would have provided for a gradual reduction of most mutual tariffs and customs restrictions, yet would have retained a higher and generally equal tariff against all nations outside the FTA. Up to the present, the EEC members, particularly the French, have insisted that the EEC will accept the FTA only if the other nations interested in membership accept all of the EEC program. Even under these conditions, the French are none too eager to expand the membership of the EEC, much less enter also into the FTA. One of the major objections raised by the French is that goods coming into an FTA country, not a member of EEC, might be transshipped duty free into the Common Market, thus avoiding a possibly higher EEC duty. The British and Italians have suggested possible ways of compromising this problem, but so far no plan has obtained French approval.

The resolution of the problem of the EEC versus the FTA is a serious one not only for Western Europe but for the United States as well. The countries of Western Europe could present a far stronger front against the menace of the U.S.S.R. if they were economically united in a single common market than if grouped into a central, well-organized EEC core with a variety of separate national entities outside it. It would be far easier for the Russians to pick off one of these nations unconnected with the common market than one of the members of an all-Western Europe Free Trade Area. The present Soviet pressures on Finland, for example, would be far less heavy were that latter country part of a smoothly functioning common market than, as it is now, far on the fringe of European economic activity.

The Mineral Base of Western Europe

Granted that the French can be made to see the value of enlarging the EEC as a long-range tool for the containment of the Soviet Union and that the British can reconcile their Commonwealth ties with membership in a common Western European market, it is further desirable to determine whether such an area possesses the capabilities for economic, as well as political, survival. A sound mineral base is as essential to the common market as is the possession of a modern manufacturing plant or a skilled labor force.

The accompanying table shows a summary of the mineral productivity not only of the present EEC nations and of Western Europe as a whole but also of the U.S.S.R. and its European satellites, and of Yugoslavia — the one nation that at present can be classified as neither East nor West. From this it can be seen, for example, that the EEC alone outproduces the U.S.S.R. in iron ore, steel, smelter lead, slab zinc, bauxite, mercury, barite, fluorspar, and potash — 9 commodities of the 20 for which direct comparisons can be made. When the entire Western European community is considered, zinc in ore, aluminum, and bituminous coal can be added to the 9 items already mentioned. Thus, in over half of the mineral products listed, Western Europe outproduces the Soviet Union; even if satellite production is added to that of the U.S.S.R., only zinc in ore is dropped from the Western list. In this instance, moreover, if the production of Yugoslavia is added to that of Western Europe, the balance is almost redressed. Further, if Yugoslav production of other mineral materials is added to the Western output, the West adds lead in ore to the materials in which it could outproduce the Soviets and their satellites and considerably closes the gap in others.

The most important disparity between West and East lies in petroleum, in which Eastern production is some 10 times greater than that of the West. On the other hand, in bituminous coal the West is less than 10 per cent ahead of combined Soviet-Satellite production, and this latter group mines over 3 times as much lignite as the West. Thus, the energy sources available to the East are far greater than those on which the West can locally rely, a fact which emphasizes the importance of Middle East oil to Europe.

As matters now stand, it appears probable that Western Europe can continue to compete with its eastern neighbors in mineral material production and primary processing only so long as it retains access to Middle East oil. Cut off these supplies of petroleum, and the West will in not many years be as much at the mercy of the Soviets as if conquered by force of arms. This follows because of the definite time limit on the ability of the United States and South America to supply both this hemisphere and Western Europe with petroleum in the quantities needed to remain on equal terms with a Russia in control of the Middle East.

Another weakness of the European mineral picture is one which is shared with the United States — the lack of important domestic supplies of manganese. As is true of this country, the huge tonnages of that ore required for steel-making must be brought from abroad, mainly along highly vulnerable supply lines. To a lesser extent, Western Europe's lack of sizable deposits of copper reduces its effectiveness in competition with Russia, but the routes by which copper comes to Western Europe, and countries which mine it, are less easily brought under Soviet domination.

Further examination of the table shows that the EEC and Western Europe as well, despite their large production of lead and zinc in ore, must import tremendous tonnages to make up the difference between mine and smelter outputs. The U.S.S.R. and its satellites, however, mine almost as much as they smelt of these two materials and are, therefore, far less dependent on outside sources with their concomitantly vulnerable supply lines.

Despite these deficiencies, however, Western Europe is well equipped in mineral raw materials to meet communist competition and to provide much, though not all, of the basic materials needed to support sound industrial operations on a scale at least as great as that of the U.S.S.R. and its satellites. Although the energy picture is not as bright as that of the Soviets, still the production in Western Europe of almost 550 million tons of bituminous coal a year provides a huge energy base. The picture is even better than this tonnage suggests because of the large amount of lignite mined and of the abundance of water power energy in several of the EEC and FTA countries.

(Continued on page 8)

by Political Divisions

(in thousands of tons)

EUROPEAN SATELLITES				YUGOSLAVIA			
1947-1951 Average	1955	1956	1957	1947-1951 Average	1955	1956	1957
3,489	7,763	7,622	8,001	846	1,541	1,901	2,120
6,960	15,265	16,494	16,961	428	888	977	1,131
14.4	25.3**	25.3**	35.5	38.7	31.2	32.4	37.2
18.3	30.0**	30.0**	55.0	40.2	31.2	32.4	37.2
38.6	44.2	44.5	50.5	78.2	99.3	96.3	99.3
44.7	79.9	83.0	101.1	58.1	83.3	83.5	86.5
108.0	139.0†	138.0†	143.0†	42.2	65.8	63.4	64.0
113.5	173.5	175.4	189.2	10.4	15.2	15.4	32.5
530.5	1,236.8	894.8	901.8	252.6	778.5	867.5	874.2
15.0	125.2	122.7	118.0	2.3	12.7	16.2	20.0
neg	neg	neg	neg	neg	neg	neg	neg
113.3*	554.4	568.9	463.4	12.6	4.9	5.5	6.0
0.03‡	0.03‡	0.03‡	0.03‡	0.47	0.55	0.51	0.46
neg	neg	neg	neg	320	948	1,000*	1,000*
14.8**	27.6**	27.6**	27.6**	26.4	109.1	71.0*	86.7
49.0**	90.0**	90.0**	90.0**	—	—	—	—
1,142.2**	1,522.0**	1,598.0**	1,650.0**	—	—	—	—
66.7†	na	na	314.6	173.6	223.1	251.9	308.1
2,535.7	6,911.8	6,911.8	6,911.8	1,999.3	2,983.6	2,760.0	2,589.7
94,400	134,922	136,911	143,373	1,091	1,253	1,358	1,353
169,565	311,950	321,058	348,414	10,270	15,510	17,493	18,497
39,200	95,993	96,348	na	580	2,027	2,076	2,848

In 1000's of pounds na—not available neg—negligible

SCHOLARSHIPS 1958-1959

(Continued from page 5)

Scholarship	Amt. Per Year	Recipient	Home Town	Year
		GEOLOGY AND MINERALOGY		
John and Elizabeth Holmes Teas	1000	David G. Towell	Fillmore, N. Y.	Senior
Edwin L. Drake Memorial	500	Jeffrey R. Parsons	Fairfax, Va.	Sophomore
	350	Lamont S. Beers	Palmerton	Senior
John G. Miller Memorial	500	Willard A. Lathers	Philipsburg	Freshman
Sohio Petroleum Co.	800	David Schleicher	Bloomsburg	Senior
		GEOPHYSICS AND GEOCHEMISTRY		
John and Elizabeth Holmes Teas	1000	Otis D. Slagle	Greensburg	Sophomore
	1000	William Andrake	Gibsonia	Junior
	1000	Stephen A. Kirsch	Lancaster	Sophomore
	1000	Charles W. Racer	York	Senior
Chevron Oil Co.	500	David J. Ward	S. Williamsport	Freshman
Edwin L. Drake Memorial	350	John C. Shank	Indiana	Senior
	350	Walter Mitronovas	Erie	Senior
	350	Allen K. Thomas	Crafton	Sophomore
	350	Roger C. Malot	Hustontown	Sophomore
		METALLURGY		
American Society for Metals	500	George P. Sabol	Clairton	Sophomore
Cooperative Program in Metallurgy	370	John W. Kochera	Latrobe	Junior
	370	George P. Marino	Vandergrift	Sophomore
	370	William A. Nystrom	Emporium	Senior
	370	Russel L. McCarron	Wayne	Junior
	370	Ronald P. Pallini	Leechburg	Sophomore
	370	Joseph A. Langus	Belle Vernon	Junior
	370	Foster C. Garrison	Johnstown	Freshman
	370	Jack LaVerne Hardt	Mars	Freshman
	370	Nelson W. Kleintop, Jr.	Bowmanstown	Freshman
	370	Raymond Koelsch	Chicora	Freshman
	370	David R. Reynolds	Freeport, Maine	Freshman
	370	Charles Carson	Philadelphia	Sophomore
	300	James N. Fleck	Danville	Sophomore
	370	Larry A. Niemond	Lewistown	Sophomore
	370	Andrew C. Nyce	Ridley Park	Junior
	370	Paul E. Shattuck	Warren	Senior
	370	David A. Shores	Towanda	Freshman
	370	Marshall Sneiderman	Erie	Sophomore
	370	Thomas A. Szuba	Mount Pleasant	Freshman
Wilbur B. Driver Co.	650	Thomas M. Barnes	Glenview, Ill.	Junior
International Nickel Co.	350*	William E. Booker	Pittsburgh	Junior

* Plus Tuition.

MINERAL INDUSTRIES

January 1959

U.Ed. 9-211

Professor Mitchell Granted Leave of Absence

A LEAVE OF ABSENCE from February 1 to July 31, 1959, has been granted David R. Mitchell, professor and chairman of the division of mineral engineering at the University.

Professor Mitchell plans to work on the third edition of his book, *Coal Preparation,* published by the American Institute of Mining, Metallurgical and Petroleum Engineers.

He plans to write a chapter on coal preparation for the National Research Council's book, *Chemistry of Coal Utilization.* Professor Mitchell also will make special studies of future technical manpower requirements in the mining industry and plans to travel.

A graduate of Penn State for both his bachelor's and master's degrees, he joined the staff of the College of Mineral Industries in 1938. Since 1941 he has served as chairman of the division of mineral engineering.

MINERAL BASE OF EEC–

(Continued from page 7)

Rates of Mineral Industries Expansion

Continual publicity is given these days to the rapidity with which the U.S.S.R. is building up its extractive and primary processing mineral industries. For example, the Soviets increased their steel production from the 1947-1951 average of 25.6 million tons to 56.2 million in 1957, yet the EEC countries in the same period went from 30.2 to 66.0 million tons of steel — almost exactly the same rate of expansion. Among the nonferrous metals bauxite, aluminum, and smelter copper have expanded at almost the same rate for both areas. Soviet expansion has been somewhat greater than for the EEC countries for lead and zinc in ore and for smelter lead and zinc. Nevertheless, the increases in the EEC area have been far from small and have reached tonnages which leave large amounts for export. In barite and fluorspar, the EEC countries have progressed with appreciable greater rapidity than the U.S.S.R., and while the Soviets have increased potash output considerably above the rate of the EEC, they had a far greater unsatisfied market to fill than did the common market countries.

Conclusions

In short, the EEC and FTA areas have a mineral production base which is quite comparable to that of the U.S.S.R. and its satellites; the main deficiencies of the West lie in petroleum, manganese ore, and copper ore. For all other materials considered (with the minor exception of molybdenum), the EEC has progressed either as rapidly as the Soviets or, comparing the relative needs for increased production, on a sufficiently large scale to keep abreast of Soviet progress. It follows, therefore, that the EEC countries are well equipped with natural resources to compete economically with the U.S.S.R.; they would, however, be far better equipped to conduct such competition if the remaining nations of Western Europe could be integrated efficiently and economically into a Free Trade Area in which at least much of the program of the EEC would apply to all.

PERIODIC WIND VARIATIONS–

(Continued from page 5)

Bull. Amer. Meteor. Soc., v. 36, pp. 99-103.

13. Haurwitz, B., 1947: Comments on the sea breeze circulation. *Jour. Meteor.,* v. 4, pp. 1-8.
14. Lettau, H., 1954: Graphs and illustrations of diverse atmospheric states and processes observed during the seventh test period of the Great Plains Turbulence Field Program. Occasional Report No. 1, Atmospheric Analysis Laboratory, Geophysics Research Directorate, Cambridge, Mass.
15. Means, L. L., 1944: The nocturnal maximum occurrence of thunderstorms in the midwestern states. *Misc. Rep.* No. 16; University of Chicago Press.
16. Neyland, L. J., 1956: Change without notice. *Flying Safety,* April, pp. 16-20.
17. Raynor, G. S., 1956: Meteorological variables and the northward movement of nocturnal land bird migrants. *Auk,* v. 73, pp. 153-175.
18. Stommel, H., 1954: Serial observations of drift currents in the central North Atlantic Ocean. *Tellus,* v. 6, pp. 203-214.